06-07-00

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PATENT

Attorney's Docket No.: U 012803-6

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of Inventors:

1. ROEE **MITRANI**
2. LIOR **HORN**
3. URI **KEIDAR**
4. MOSHE **SIDI**
5. ISRAEL **CIDON**

WARNING: *The Declaration must name all of the actual inventor(s).*

For (title):
NETWORK PACKET TRACING

1. Type of Application

This new application is for a(n) (check one applicable item below):

☑ Original (nonprovisional)

☐ Design

☐ Plant

WARNING: ***Do not*** *use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. 371(c)(4) unless the International Application is being filed as a divisional, continuation or continuation-in-part application.*

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this New Application Transmittal and the documents referred to as enclosed therein are being deposited with the United States Postal Service on this date **JUNE 6, 2000 in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number EL386269387US addressed to the: Assistant Commissioner of Patents, Washington, D.C. 20231**

JENNIFER RASHKIN
(type or print name of person mailing paper)

Jennifer
(Signature of person mailing paper)

NOTE: ***Each paper or fee referred to as enclosed herein has the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 CFR 1.10(b).***

WARNING: ***Certificate of mailing (first class) or facsimile transmission procedures of 37 CFR 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.***

EXPRESS MAIL LABEL
NO.: EL386269387US

WARNING: ***Do not*** *use this transmittal for the filing of a provisional application.*

2. Benefit of Prior U.S. Application(s) (35 U.S.C. 119(e), 120, or 121)

NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

WARNING: *If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. 120, 121 or 365(c). (35 U.S.C. 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.*

WARNING: *When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional* ***must*** *be filed prior to the Saturday, Sunday or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).*

☐ The new application being transmitted claims the benefit of prior U.S. application(s) and enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

NOTE: If one of the following 3 items apply, then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED and a NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION.

☐ Divisional.

☐ Continuation.

☐ Continuation-in-Part (C-I-P).

3. Papers Enclosed That Are Required For Filing Date Under 37 CFR 1.53 (Regular) or 37 CFR 1.153 (Design) Application

22 Pages of specification

7 Pages of claims

1 Pages of Abstract

2 Sheets of drawing

☑ formal

☐ informal

WARNING: ***DO NOT*** *submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. Comments on proposed new 37 CFR 1.84. Notice of March 9, 1988 (1990 O.G. 57-62).*

NOTE: "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm. (⅝ inch) down from the top of the page." 37 C.F.R. 1.84(c).

(complete the following, if applicable)

☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)". 37 C.F.R. 1.84(b).

4. Additional papers enclosed

☐ Preliminary Amendment

☐ Information Disclosure Statement (37 CFR 1.98)

☐ Form PTO-1449

☐ Citations

☐ Declaration of Biological Deposit

☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.

☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative

☐ Special Comments

☐ Other

5. Declaration or oath

☐ Enclosed

executed by *(check **all** applicable boxes)*

☐ inventors.

☐ legal representative of inventors. 37 CFR 1.42 or 1.43

☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.

☐ This is the petition required by 37 CFR 1.47 and the statement required by 37 CFR 1.47 is also attached. *See item 13 below for fee.*

☑ Not Enclosed.

WARNING: *Where the filing is a completion in the U.S. of an International Application but where a declaration is not available or where the completion of the U.S. application contains subject matter in addition to the International Application the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.*

☑ Application is made by a person authorized under 37 CFR 1.41(c) on behalf of *all the above named inventors.* (The declaration or oath, along with the surcharge required by 37 CFR 1.16(e) can be filed subsequently).

NOTE: It is important that all the correct inventor(s) are named for filing under 37 CFR 1.41(c) and 1.53(b).

☐ Showing that the filing is authorized. *(Not required unless called into question. 37 CFR 1.41(d).)*

6. Inventorship Statement

WARNING: *If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.*

The inventorship for all the claims in this application are:

☐ The same

☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,

7. Language

NOTE: An application including a signed oath or declaration may be filed in a language other than English. A verified English translation of the non-English language application and the processing fee of $130.00 required by 37 CFR 1.17(k) is required to be filed with the application or within such time as may be set by the Office. 37 CFR 1.52(d).

NOTE: A non-English oath or declaration in the form provided or approved by the PTO need not be translated. 37 CFR 1.69(b).

☑ English

☐ non-English

☐ the attached translation is a verified translation. 37 CFR 1.52(d).

8. Assignment

☑ An assignment of the invention to ATTUNE NETWORKS LTD.

☑ is attached. A separate ☑ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

☐ will follow.

NOTE: "If an assignment is submitted with a new application, send two separate letters—one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

WARNING: *A newly executed "CERTIFICATE UNDER 37 CFR 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993. 1150 O.G. 62-64.*

9. Certified Copy

Certified copy of application

Country	Appln. No.	Filed

from which priority is claimed

☐ is attached.

☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 CFR 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. 120 is itself entitled to priority from a prior foreign application then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

10. Fee Calculation (37 CFR 1.16)

A. ☑ Regular Application

Claims as Filed

Number Filed			Number Extra		Rate	Basic Fee 37 CFR 1.16(a) $690.00
Total Claims (37 CFR 1.16(c))	31 - 20	=	11	x $	18.00	198.00
Independent Claims (37 CFR 1.16(b))	3 - 3	=	0	x $	78.00	
Multiple dependent claim(s), if any (37 CFR 1.16(d))				+ $	260.00	

☐ Amendment cancelling extra claims enclosed.

☐ Amendment deleting multiple-dependencies enclosed.

☐ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 CFR 1.16(d).

Filing Fee Calculation $

B. ☐ Design application ($310.00 — 37 CFR 1.16(f))

Filing Fee Calculation $

C. ☐ Plant application ($480.00 — 37 CFR 1.16(g))

Filing Fee Calculation $

11. Small Entity Statement(s)

☑ Verified Statement(s) that this is a filing by a small entity under 37 CFR 1.9 and 1.27 is(are) attached or has been filed.

Filing Fee Calculation (50% of **A**, **B** or **C** above) $

NOTE: Any excess of the full fee paid will be refunded if a verified statement and a refund request are filed within 2 months of the date of timely payment of a full fee. 37 CFR 1.28(a).

12. Request for International-Type Search (37 CFR 1.104(d)) *(Complete, if applicable)*

☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. Fee Payment Being Made At This Time

☑ Not Enclosed

☑ No filing fee is to be paid at this time. *(This and the surcharge required by 37 CFR 1.16(e) can be paid subsequently.)*

☐ Enclosed

☐ basic filing fee $

☐ Recording assignment
($40.00; 37 CFR 1.21(h)) (See attached "COVER SHEET FOR ASSIGNMENT ACCOMPANYING NEW APPLICATION.")

☐ Petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached.
($130.00; 37 CFR 1.47 and 1.17(h)) $

☐ For processing an application with a specification in a non-English language.
($130.00; 37 CFR 1.52(d) and 1.17(k)) $

☐ Processing and retention fee
($130.00; 37 CFR 1.53(d) and 1.21(l))

☐ Fee for international-type search report
($40.00; 37 CFR 1.21(e)). $

NOTE: 37 CFR 1.21(l) establishes a fee for processing and retaining any application which is abandoned for failing to complete the application pursuant to 37 CFR 1.53(d) and this, as well as the changes to 37 CFR 1.53 and 1.78, indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid or the processing and retention fee of §1.21(l) must be paid within 1 year from notification under §53(d).

Total fees enclosed $

14. Method of Payment of Fees

☐ Check in the amount of $

☐ Charge Account No. 12-0425 in the amount of $

A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 CFR 1.22(b).

15. Authorization to Charge Additional Fees

WARNING: *If no fees are to be paid on filing, the following items should not be completed.*

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.*

☐ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 12-0425.

☐ 37 CFR 1.16(a), (f) or (g) (filing fees)

☐ 37 CFR 1.16(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 CFR 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

☐ 37 CFR 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

☐ 37 CFR 1.17 (application processing fees)

WARNING: *While 37 CFR 1.17(a), (b), (c) and (d) deal with extensions of time under §1.136(a), this authorization should be made only with the knowledge that: "Submission of the appropriate extension fee under 37 C.F.R. 1.136(a) is to no avail unless a request or petition for extension is filed." (Emphasis added). Notice of November 5,1985 (1060 O.G. 27)*

☐ 37 CFR 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 CFR 1.311(b))

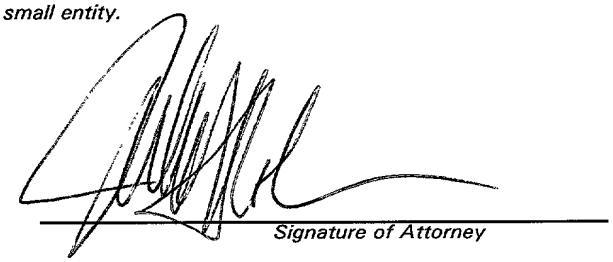
NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 CFR 1.311(b).

NOTE: 37 CFR 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application ... prior to paying, or at the time of paying, ... issue fee". From the wording of 37 CFR 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

16. Instructions As To Overpayment

☐ credit Account No. 12-0425

☐ refund



Signature of Attorney

Reg. No. 20,302

Tel. No. (212) 708-1887

Julian H. Cohen
Ladas & Parry
26 West 61 Street
New York, NY 10023

☑ **Incorporation by reference of added pages**

(Check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)

☐ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added ___

☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added ___

☑ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added 4

☐ **Statement Where No Further Pages Added**

(If no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item:)

☐ This transmittal ends with this page.

Applicant or Patentee: _____ Attorneys Docket No.: _____
Serial or Patent No.: _____
Filed or Issued: _____
For: _____

VERIFIED STATEMENT [DECLARATION] CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) and 1.27(c)) - SMALL BUSINESS CONCERN

I hereby declare that I am

[ ] the owner of the small business concern identified below;
[X] an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN ATTUNE NETWORKS LTD.
ADDRESS OF CONCERN P.O. Box 305, Yokneam Illit 20692, Israel

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.
I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention entitled NETWORK PACKET TRACING, by inventor(s) Roee Mitrani, Kior Horn, Uri Keidar, Moshe Sidi and Israel Cidon
described in

[X] the specification filed herewith
[ ] application serial no._____, filed _____
[ ] patent no. _____, issued _____

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(c). *NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averting to their status as small entities. (37CFR 1.27).

FULL NAME _____
ADDRESS _____
[ ] INDIVIDUAL [ ] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

FULL NAME _____
ADDRESS _____
[ ] INDIVIDUAL [ ] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR {1.28(b)).
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING AHARON BEN-NUN
TITLE OF PERSON OTHER THAN OWNER CFO
ADDRESS OF PERSON SIGNING P.O. Box 305 YOKNEAM ILLIT 20692 ISRAEL

SIGNATURE _____ DATE May 24, 2000

35428S2

NETWORK PACKET TRACKING

FIELD OF THE INVENTION

The present invention relates generally to communication networks, and specifically to testing and fault discovery in communication networks.

BACKGROUND OF THE INVENTION

Communication networks are in wide use in many technological fields including distributed computing, data exchange and telecommunication applications. Communication networks generally include many nodes, such as bridges, LAN switches, routers, cross-connections and telephone switches. The networks further include communication links, such as cables, point-to-point radio connections and optical fibers, which connect the nodes. The networks also include ports, generally within some of the nodes, for attaching external devices such as computers, terminals, handsets, and multiplexers. These external devices are referred to as end-points, or hosts.

A major issue in both newly-deployed and existing communication networks is testing and trouble-shooting, i.e., checking whether the network is operating according to its specifications and, if not, determining the cause of the network's inadequate performance (for example, the identity of a faulty unit or link). Dedicated point-to-point testing equipment is a commonly-used network testing tool. Such equipment is described, for example, in U.S. Patent 5,477,531, whose disclosure is incorporated herein by reference. Usually, dedicated point-to-point testing equipment requires two users to coordinate their operations in order to identify a misbehaving component of the network. To test a large

network, the testing equipment must be moved between many ports of the network.

End-to-end tests of network response times and delays provide useful information regarding the operational status of the network. Such tests are helpful in determining that a fault or network overload has occurred. For example, in end-to-end timing testing, packets of a given size are sent from a source node to a destination node, which measures and reports the packet arrival times. In response time testing, the destination node sends a correlated echo packet back to the source, which measures and reports the round-trip time elapsed between sending the original packet and receiving the echo packet. When there is excessive delay or jitter in delivery of the packets, it is an indication that a problem exists. End-to-end tests by themselves, however, provide no further information as to the source and location of the problem within the network.

RMON (Remote Network Monitoring) is a family of standards defining information that a network administrator can use to monitor, analyze, and troubleshoot a distributed network from a central site. These standards, which are an extension of the Simple Network Management Protocol (SNMP), specify the information that a network monitoring system is expected to provide. RMON first became a standard in 1992 in Request for Comments (RFC) 1271 of the Internet Engineering Task Force (IETF). It is currently specified as part of the IETF Management Information Base (MIB) in RFC 1757, entitled "Remote Network Monitoring Management Information Base." More recently, RMON Version 2 (sometimes referred to as "RMON2") was specified in IETF

RFC 2021. These standard documents are incorporated herein by reference.

RMON can be supported by hardware monitoring devices (known as "probes") and/or by software agents embedded in network nodes and other elements. For example, Cisco's line of LAN switches includes software in each switch that can trap information as traffic flows through the switch and record the information in its MIB. RMON specifies nine kinds of information to be collected by probes and agents, including packets sent, bytes sent, packets dropped, statistics by host and by conversation between two sets of addresses, and certain kinds of events that have occurred. RMON information groups eight and nine are based on trapping or capturing specified types of packets, to provide network alarms and enable traffic decoding and analysis. RMON probes and agents are typically controlled by a management station, using SNMP commands. These SNMP commands are described, for example, in *SNMP, SNMPv2 and RMON: Practical Network Management*, by William Stallings (Second Edition, Addison Wesley, 1996), which is incorporated herein by reference.

Other types of network monitoring tools are also known in the art. For example, Network Associates (Santa Clara, California) offer the "Sniffer" line of network analysis products. The capabilities of these products include packet capturing, whereby filters based on pattern matching and/or Internet Protocol (IP) addresses enable selected frames to be captured and displayed. Further details regarding these products are available at www.sniffer.com. Another tool that is commonly used in diagnosing IP-based routing is TraceRoute, which is described, for example, by Huitema, in *Routing in the*

Internet (Prentice Hall, 1995), page 45, which is incorporated herein by reference. TraceRoute is used to determine a network path that an IP packet could traverse from a specific host to reach an intended destination, and to identify possible network problems in this context. It is available as an application in most operating systems that implement IP.

TraceRoute discovers intermediate hops traversed by a packet by adjusting the "Time to Live" (TTL) parameter in each of a sequence of IP packets. It uses the fact that at each hop as the packet passes through the network, the TTL is reduced by one, and an error message is sent by a router that receives an IP packet with a zero TTL. In each packet in the sequence sent from the host, the TTL parameter is incremented by one. TraceRoute monitors the error messages sent back from the routers in the network with respect to each of the packets in turn, and thus tracks the packets downstream progressively until the ultimate destination has been reached. When multiple paths are available in the network, however (as is the case in most large IP networks), there is no assurance that all of the packets in the sequence will follow the same path. In this context, the information provided by TraceRoute is of little use in end-to-end tracking of packets or in determining packet transmission delays over different hops along the route.

U.S. Patent 5,812,529, whose disclosure is incorporated herein by reference, describes a system and method for acquiring network performance data, built around a "mission server," which interfaces with clients to receive requests for "missions." A typical mission includes operations such as transmission and reception of

data packets among devices connected to segments of the network. The mission is performed and/or supported by "sentries," typically software agents running on the network devices. The sentries carry out mission operations in response to commands from the mission server, and report back to the mission server on the mission results.

U.S. Patents 5,838,919 and 5,881,237, whose disclosures are incorporated herein by reference, describe methods, systems and computer program products for testing of network performance using test scenarios that simulate actual communications traffic between network end-points. Specific test protocols are assigned to end-point nodes on the network. Typically, the nodes are paired, and one of the nodes in the pair communicates the protocol to the other, associated node. A console node sets up the test protocols, initiates their execution and receives data on the test performance from the end-point nodes.

SUMMARY OF THE INVENTION

It is an object of some aspects of the present invention to provide improved methods and apparatus for locating faults within communication networks.

It is another object of some aspects of the present invention to provide improved methods and apparatus for evaluation of the performance of communication networks.

In preferred embodiments of the present invention, a distributed testing system for evaluation and/or testing of a communication network comprises a plurality of capture-capable network agents (CCNAs), which are coupled to the network at different, respective locations and are controlled by a testing center. The CCNAs intercept packets meeting a filtering criterion that is specified by the testing center, and report to the testing center on the arrival of the specified packets. In intercepting the packets, the CCNAs preferably copy the packets "on the fly," without stopping or delaying the packets. By collecting reports from multiple CCNAs that intercept a given packet passing through the network from one end-point to another, the testing center is able to analyze details of the route and timing of the packet within the network, over multiple links and nodes simultaneously. It thus overcomes a shortcoming of network diagnostic systems known in the art, which are largely limited to determining end-to-end information regarding packet transmission.

Preferably, the CCNAs comprise software agents associated with an existing piece of network equipment, such as a switch or router. Alternatively or additionally, CCNAs may comprise stand-alone probes. In either case, the CCNAs typically comprise standard

elements, such as RMON agents or probes, which already exist in many networks. The present invention takes advantage of the capabilities of such elements to identify and capture packets meeting the filtering criterion, for example, having a specified bit pattern, address and/or protocol. The CCNAs are directed by the testing center, in accordance with a selected test scenario, to perform functions such as storing all or a part of the specified packets and recording their times of arrival, as well as processing the timing or other information and passing it back to the testing center. While these CCNA functions are within the capabilities of standard, existing agents and probes, the testing center controls the CCNAs and processes the information that they provide in a novel fashion, so as to provide network diagnostic information that is not offered by systems known in the art.

In some preferred embodiments of the present invention, the testing system comprises one or more traffic agents coupled to nodes and/or hosts of the network. The traffic agents act as artificial users of the network by establishing connections and transmitting and receiving packets of data. The testing center instructs one of the traffic agents to send a sequence of packets with a specified identifying feature through the network to a destination agent or host. The testing center instructs the CCNAs to intercept each packet with this feature and to report its times of arrival. Preferably, the destination agent or host echoes the packets back to the original traffic agent, and the CCNAs are instructed to intercept and report on the echoed packets, as well. The testing center processes the information received from each of the CCNAs to determine

the exact route of each of the packets through the network and the time elapsed in each link along the route. The route and timing data are preferably used to find specific nodes or links that had slow response and/or high jitter, thus indicating the likely location of network problems.

There is therefore provided, in accordance with a preferred embodiment of the present invention, a method for testing of a communication network having a plurality of end-points, using one or more network agents coupled to the network at respective locations, the method including:

specifying at least one packet filtering criterion;

transmitting one or more data packets meeting the at least one criterion through the network from one of the end-point to another;

intercepting at least one of the data packets meeting the criterion using the network agents at one or more of the respective locations in the network traversed by the at least one of the data packets;

recording information regarding the at least one intercepted packet at the one or more respective locations; and

processing the recorded information to analyze a route of the at least one intercepted packet through the network.

Preferably, specifying the at least one packet filtering criterion includes specifying a pattern of data to appear in the one or more packets to be transmitted. Additionally or alternatively, specifying the at least one packet filtering criterion includes specifying information associated with a data protocol in accordance with which the packets are to be transmitted.

Preferably, specifying the information associated with the data protocol includes specifying a Transport Control Protocol (TCP) sequence number to be assigned to the one or more packets to be transmitted, wherein the TCP sequence number most preferably includes an acknowledgment sequence number.

Preferably, the plurality of end-points includes a source end-point and a destination end-point, and transmitting the one or more data packets includes transmitting original packets from the source end-point to the destination end-point, and receiving echo packets returned from the destination end-point, both the original and the echo packets meeting the at least one criterion.

In a preferred embodiment, the network agents include Remote Network Monitoring (RMON) elements, in accordance with one or more applicable standards defined by the Internet Engineering Task Force (IETF). Preferably, the network agents include software processes running on nodes of the network at the respective locations. Alternatively or additionally, the network agents include stand-alone probes.

Preferably, recording the information includes recording times of arrival of the at least one intercepted packet at the respective locations, wherein processing the recorded information includes determining, responsive to the times of arrival, transit times of the at least one intercepted packet over network links connected to the respective locations and traversed by the at least one intercepted packet. Most preferably, intercepting the at least one of the data packets includes intercepting multiple data packets, and wherein

determining the transit times includes detecting a jitter in transit of the packets over one of the links.

Additionally or alternatively, the plurality of end-points includes a source end-point and a destination end-point, wherein transmitting the one or more data packets includes transmitting original packets from the source end-point to the destination end-point, and receiving corresponding echo packets returned from the destination end-point, both the original and the echo packets meeting the criterion, and wherein determining the transit times includes determining round-trip transit times by intercepting both the original packets and the corresponding echo packets. Most preferably, transmitting the original packets includes transmitting a Transport Control Protocol (TCP) initialization packet having a first, specified TCP sequence number, and receiving the echo packets includes receiving a TCP connection acknowledgment packet having a second TCP sequence number, which is determined responsive to the first TCP sequence number.

In a preferred embodiment, processing the recorded information includes determining which of a plurality of links in the network were traversed by the at least one intercepted packet.

There is also provided, in accordance with a preferred embodiment of the present invention, apparatus for testing of a communication network having a plurality of endpoints and nodes connected by links, including:

one or more network agents, adapted to be coupled to the network at respective locations and to intercept data packets that meet a predetermined packet filtering criterion and traverse the respective locations, and to

record information regarding the intercepted data packets; and

a testing center, configured to convey the criterion to the network agents and to cause one or more data packets meeting the criterion to be transmitted through the network from one of the end-points to another, and to process the information recorded by the network agents in order to analyze a route of the at least one intercepted packet through the network.

Preferably, the apparatus includes at least one traffic agent, which is configured to receive instructions from the testing center and, responsive thereto, to transmit the packets meeting the criterion from the one of the end-points to the other.

There is further provided, in accordance with a preferred embodiment of the present invention, a computer software product for testing of a communication network having a plurality of end-points, using one or more network agents coupled to the network at respective locations, the product including a computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to specify a packet filtering criterion and to engender transmission of one or more data packets meeting the criterion through the network from one of the end-points to another, such that at least one of the data packets meeting the criterion is intercepted using the network agents at the respective locations in the network traversed by the packets, which agents record information regarding the at least one intercepted packet at the respective locations, and which instructions further cause the computer to receive and process the recorded

information so as to analyze a route of the at least one intercepted packet through the network.

The present invention will be more fully understood from the following detailed description of the preferred embodiments thereof, taken together with the drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph that schematically illustrates a communication network to which a distributed testing system is coupled, in accordance with a preferred embodiment of the present invention;

Fig. 2 is a flow chart that schematically illustrates a method for analyzing transit times of packets over links in a communication network, in accordance with a preferred embodiment of the present invention; and

Fig. 3 is a flow chart that schematically illustrates a method for analyzing transit times of packets over links in a communication network, in accordance with another preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 is a block diagram that schematically illustrates a distributed testing system 20, used to perform diagnostic testing on a network 22, in accordance with a preferred embodiment of the present invention. Network 22 may comprise substantially any network known in the art that is capable of transmitting data packets, such as a local- or wide-area network (LAN or WAN), a public switched telephone network (PSTN), the Internet or an intranet, an asynchronous transfer mode (ATM) network, an optical or wireless network, or some combination of these different types. The network comprises switching and routing hardware, represented schematically in Fig. 1 as nodes 30.

Testing system 20 comprises one or more end-point traffic agents 24, 26, which are coupled to ports of network 22. Typically, multiple host computers, such as a host 28, are also connected to and make use of the network. Preferably, the traffic agents serve as both traffic generators, transmitting packets through the network, and as traffic analyzers, receiving packets and assembling information regarding the received packets, as described in detail hereinbelow. Traffic agents 24 and 26 are typically implemented as software processes running on host computers connected to the network. Alternatively, some or all of these hosts may comprise add-on hardware devices to accommodate the traffic agents, particularly when network 22 is a very fast network, such as an ATM or a Gigabit Ethernet network. Further alternatively or additionally, the traffic agents may be implemented as stand-alone devices, independent of host computers. Although only two traffic agents are

shown in Fig. 1, system 20 may comprise substantially any reasonable number of agents.

Testing system 20 also comprises capture-capable network agents (CCNAs) 32, 34, 36, 38, 40 (also referred to herein simply as network agents, and marked "NA" for short in Fig. 1). As shown in the figure, these CCNAs typically comprise software agents or combinations of hardware and software elements that are associated with one or more of nodes 30. Alternatively, the CCNAs may comprise stand-alone probes, coupled to the network at nodes 30 or at locations along network links intermediate the nodes. The CCNAs are characterized by an ability to intercept, or capture, specified types of packets that pass through the nodes or links to which they are coupled. Preferably, the type of packet to intercept is specified in terms of a filtering criterion, such as a certain bit pattern occurring in the packets. Most preferably, the pattern is defined in a manner that allows variations, using methods such as "wild cards" and "don't care" entries, as are known in the art of string matching. Alternatively or additionally, the packet type is specified in terms of a protocol or packet address, or substantially any other distinguishing packet characteristic.

When one of the CCNAs intercepts a packet of the specified type, it preferably records the time of interception and, optionally, stores all or a specified portion or characteristic of the packet. Typically, in a given test scenario, a CCNA intercepts multiple packets of the specified type or types. In this case, the CCNA may store all of the packets or portions thereof, or alternatively, it may record only certain parameters or a combination of parameters, such as the numbers and times

of arrivals of the packets, the sizes of the packets, or the values of certain fields in the packets. Most preferably, the CCNA also processes the information that it collects in the course of a test and provides a summary.

Preferably, the CCNAs comprise RMON agents or probes, as specified by the above-mentioned IETF standards. Alternatively or additionally, the CCNAs may comprise other types of network traffic analyzers known in the art, such as the above-mentioned "Sniffer" analyzers. Further alternatively, the CCNAs may comprise dedicated devices or software agents for carrying out the test methods described hereinbelow. Substantially any type of network agent or probe may be used in the context of the present invention, so long as it has the requisite packet interception and reporting capabilities. Although Fig. 1 shows a network of low complexity, so that system 20 includes relatively few CCNAs, the principles of the present invention are equally applicable to networks of greater size and complexity, for which test systems with greater numbers of CCNAs are typically used.

System 20 further includes a testing center 42, which is preferably implemented as a software process executed at a network management host. The host of testing center 42 preferably comprises a graphical workstation or a personal computer. The software for the testing center, as well as software for carrying out the functions of the traffic agents and CCNAs, is typically conveyed to the respective computers via network 22. Alternatively, the software may be supplied on tangible media, such as CD-ROM or non-volatile memory, for installation on the respective computers. Preferably, testing center 42 communicates through network 22 with

traffic agents 24 and 26, as well as with CCNAs 32-40. Alternatively or additionally, different communication apparatus, independent of network 22, such as modem dialup lines or Internet connections, are used to communicate with some or all of the traffic agents and/or CCNAs.

Testing center 42 preferably conducts tests by transmitting one or more commands to at least one of the traffic agents and CCNAs, and subsequently receiving reports from the agents. Preferably, testing center 42 processes the reports, evaluates network 22 based on the reports and displays test results to a network operator. The tests may be initiated by the operator, or they may be carried out automatically by the testing center on a predetermined schedule or when a fault condition is suspected. When the tests are carried out automatically, and a fault condition is detected, the testing center preferably generates an alarm, so as to notify the operator that a fault has occurred. Further aspects of testing system 20 are described in U.S. Patent Application 09/164,488, and in another U.S. patent application entitled, "Analysis of Network Performance," filed April 24, 2000. Both of these applications are assigned to the assignee of the present patent application, and their disclosures are incorporated herein by reference.

Fig. 2 is a flow chart that schematically illustrates a method for testing of packet transmission through network 22, in accordance with a preferred embodiment of the present invention. This method makes use of traffic agents 24 and 26 and of CCNAs 32, 34, 36, 38, 40. All of these elements are capable of carryout out their functions in the context of this testing method

substantially without interrupting normal service to network users.

At an initialization step 50, testing center 42 instructs traffic agent 24 to send packets to traffic agent 26 having a certain, specified bit pattern. Traffic agent 26 is instructed to respond by returning echo packets with the same specified bit pattern, or with another specified bit pattern, back to traffic agent 24. Each packet is also preferably identified by a packet serial number, used by both of the traffic agents, in order to associate each packet returned by traffic agent 26 with the original packet from traffic agent 24 that it is echoing. At a CCNA notification step 52, testing center 42 informs the CCNAs of the bit pattern that is to be included in the packets sent by traffic agents 24 and 26. The CCNAs are instructed to intercept all packets having the specified bit pattern or patterns, and to record their respective times of arrival. At a packet capture step 54, the test agents begin transmitting packets, and the CCNAs intercept them as instructed. A typical record of an intercepted packet is shown by way of example in Table I:

TABLE I - PACKET TRANSIT TIMES (MS)

	Traffic agent 24	CCNA 36	CCNA 34	Traffic agent 26
Transmitted packet	0	20	90	100
Echo packet	200	180	110	100
Round trip	200	160	20	0

At the conclusion of the test or a portion thereof, typically after a certain, specified number of packets

have been transmitted and recorded, the traffic agents and CCNA report the test results to testing center 42, at a test reporting step 56. The reported results may comprise raw results, as shown in the table above, or alternatively or additionally, the test agents and CCNAs may provide a summary report and representative statistics. The testing center then analyzes the results, at a link analysis step 58, to find links or subnets in network 22 that may be faulty.

In the specific example of Table I, traffic agent 24 reports that the packet round-trip time to traffic agent 26 is 200 ms. (The time required for agent 26 to respond has been neglected for simplicity.) CCNA 36 reports a 20 ms delay in receiving the packet from traffic agent 24. CCNA 34 reports a 70 ms delay, and traffic agent 26 reports a 10 ms delay. Testing center 42 concludes that the fault responsible for the slow response in transmissions between traffic agent 24 and 26 is in the link between CCNAs 34 and 36.

In actual networks, the times of arrival and transmission of the packets will not be as orderly as those shown in Table I. In large, distributed networks, such as the Internet, for example, the clocks operating at the different nodes 30 are not generally synchronized. Therefore, the packet interception times read by the different CCNAs cannot be directly compared with one another, and it is not possible to measure transmission delays accurately in a one-way transmission of a packet. For this reason, the round-trip travel time shown in the last row of the table is useful, as it inherently cancels out the effect of the lack of clock synchronization. The round-trip time shown in each column gives the exact round-trip time of the packet between the respective CCNA

and traffic agent 26, referred only to the respective clock of the CCNA. The individual link times can then be determined by simple arithmetic.

Another aspect of actual networks not shown by Table I is packet-to-packet jitter, wherein the transit times of successive packets over a given link typically vary. Furthermore, in many networks, such as Internet Protocol (IP) networks, successive packets between the same end-points may be sent over different routes, through different nodes. A summary of the results of the test shown in Fig. 2 preferably shows the numbers of packets sent through each of the relevant CCNAs in system 20, together with the respective transmission delays and jitter. Jitter in one of the links will lead to comparable jitter in the total transit time between traffic agents 24 and 26. The test of Fig. 2 enables test center 42 to determine which of the links is responsible for the jitter.

Still another feature of testing network 22 using the method of Fig. 2 is the ability to track packets through the network. For each packet, only those CCNAs along the packet's route are able to capture it. Thus, the route of an individual packet can be determined by observing which CCNAs intercepted the packet and at what respective delays. This procedure thus provides the exact route of the packet, rather than the uncertain and possibly inaccurate information provided by TraceRoute (as described in the Background of the Invention.) Similarly, if the summary report conveyed to testing center 42 shows that very few or no packets traversed one of the CCNAs, such as CCNA 40, it can be concluded that the corresponding network link is being underused. This can lead to excessive traffic and jitter on the

alternative links. On the other hand, the summary report may show excessive routing diversity, i.e., too many different routes being used, which can be indicative of routing problems in some networks, such as IP networks.

Fig. 3 is a flow chart that schematically illustrates another method for testing packet transmission through network 22, in accordance with a preferred embodiment of the present invention. This method is similar to that shown in Fig. 2, except that in this case, packets are transmitted between traffic agent 24 and host 28, which is not a traffic agent and therefore cannot be programmed by testing center 42. Hence, at an initialization step 60, the testing center initializes only traffic agent 24, instructing the traffic agent to transmit packets to host 28. The host cannot be made to return echo packets containing a predetermined bit pattern, as in the embodiment of Fig. 2. Instead, system 20 takes advantage of features of standard communication protocols that enable the CCNAs to recognize and intercept the echo packets, as well as the original packets transmitted by the traffic agent. Testing center 42 instructs traffic agent 24 to send packets using one of these features.

For example, in some protocols, such as the Transport Control Protocol (TCP), every packet carries a protocol sequence number, which is initialized to an arbitrary value by the host initiating a communication. The sequence number acknowledged by the echo packet is given simply by incrementing the number of the original packet by one. Thus, at a sequence number setting step 62, traffic agent 24 is instructed to send packets to host 28 with certain TCP sequence numbers. Each packet will be echoed by the host with a TCP acknowledgment

sequence number incremented by one. The testing center instructs the CCNAs to intercept the packets having the appropriate, predetermined TCP sequence numbers in the appropriate header fields. Other packet features may be used as additional filtering parameters if desired. The CCNAs intercept the packets by their sequence numbers at a packet capture step 64. A reporting step 66 and an analyzing step 68 are then carried out in similar fashion to their counterparts in Fig. 2 (except that there is no report from traffic agent 26).

While preferred embodiments are described herein for the most part with reference to tests involving transmission of packets between a pair of network end-points, the principles of the present invention can also be applied in more complex test scenarios. For example, multiple traffic agents may send packets simultaneously or sequentially, so as to put pressure on a particular network link. As another example, the CCNAs may be configured to intercept packets having a known pattern that is generated by a particular application, in which case no dedicated traffic agents are required. All such variations are considered to be within the scope of the present invention.

It will thus be appreciated that the preferred embodiments described above are cited by way of example, and that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove, as well as variations and modifications thereof which would occur to persons skilled in the art upon reading the foregoing description and which are not disclosed in the prior art.

CLAIMS

1. A method for testing of a communication network having a plurality of end-points, using one or more network agents coupled to the network at respective locations, the method comprising:

specifying at least one packet filtering criterion;

transmitting one or more data packets meeting the at least one criterion through the network from one of the end-point to another;

intercepting at least one of the data packets meeting the criterion using the network agents at one or more of the respective locations in the network traversed by the at least one of the data packets;

recording information regarding the at least one intercepted packet at the one or more respective locations; and

processing the recorded information to analyze a route of the at least one intercepted packet through the network.

2. A method according to claim 1, wherein specifying the at least one packet filtering criterion comprises specifying a pattern of data to appear in the one or more packets to be transmitted.

3. A method according to claim 1, wherein specifying the at least one packet filtering criterion comprises specifying information associated with a data protocol in accordance with which the packets are to be transmitted.

4. A method according to claim 3, wherein specifying the information associated with the data protocol comprises specifying a Transport Control Protocol (TCP) sequence number to be assigned to the one or more packets to be transmitted.

5. A method according to claim 4, wherein the TCP sequence number comprises an acknowledgment sequence number.

6. A method according to claim 1, wherein the plurality of end-points comprises a source end-point and a destination end-point, and

wherein transmitting the one or more data packets comprises transmitting original packets from the source end-point to the destination end-point, and receiving echo packets returned from the destination end-point, both the original and the echo packets meeting the at least one criterion.

7. A method according to claim 1, wherein the network agents comprise Remote Network Monitoring (RMON) elements, in accordance with one or more applicable standards defined by the Internet Engineering Task Force (IETF).

8. A method according to claim 1, wherein the network agents comprise software processes running on nodes of the network at the respective locations.

9. A method according to claim 1, wherein the network agents comprise stand-alone probes.

10. A method according to claim 1, wherein recording the information comprises recording times of arrival of the at least one intercepted packet at the respective locations.

11. A method according to claim 10, wherein processing the recorded information comprises determining, responsive to the times of arrival, transit times of the at least one intercepted packet over network links

connected to the respective locations and traversed by the at least one intercepted packet.

12. A method according to claim 11, wherein intercepting the at least one of the data packets comprises intercepting multiple data packets, and wherein determining the transit times comprises detecting a jitter in transit of the packets over one of the links.

13. A method according claim 11, wherein the plurality of end-points comprises a source end-point and a destination end-point, and

wherein transmitting the one or more data packets comprises transmitting original packets from the source end-point to the destination end-point, and receiving corresponding echo packets returned from the destination end-point, both the original and the echo packets meeting the criterion, and

wherein determining the transit times comprises determining round-trip transit times by intercepting both the original packets and the corresponding echo packets.

14. A method according to claim 13, wherein transmitting the original packets comprises transmitting a Transport Control Protocol (TCP) initialization packet having a first, specified TCP sequence number, and

wherein receiving the echo packets comprises receiving a TCP connection acknowledgment packet having a second TCP sequence number, which is determined responsive to the first TCP sequence number.

15. A method according to claim 1, wherein processing the recorded information comprises determining which of a plurality of links in the network were traversed by the at least one intercepted packet.

16. Apparatus for testing of a communication network having a plurality of endpoints and nodes connected by links, comprising:

one or more network agents, adapted to be coupled to the network at respective locations and to intercept data packets that meet a predetermined packet filtering criterion and traverse the respective locations, and to record information regarding the intercepted data packets; and

a testing center, configured to convey the criterion to the network agents and to cause one or more data packets meeting the criterion to be transmitted through the network from one of the end-points to another, and to process the information recorded by the network agents in order to analyze a route of the at least one intercepted packet through the network.

17. Apparatus according to claim 16, and comprising at least one traffic agent, which is configured to receive instructions from the testing center and, responsive thereto, to transmit the packets meeting the criterion from the one of the end-points to the other.

18. Apparatus according to claim 17, wherein the packet filtering criterion comprises a pattern of data that is included in the packets transmitted by the at least one traffic agent.

19. Apparatus according to claim 18, wherein the at least one traffic agent comprises first and second traffic agents at respective network endpoints, and

wherein responsive to receiving one of the packets with the pattern of data transmitted by the first traffic agent, the second traffic agent returns a data packet

comprising the pattern of data to the first traffic agent.

20. Apparatus according to claim 17, wherein the packet filtering criterion comprises information associated with a data protocol in accordance with which the traffic agent transmits the packets.

21. Apparatus according to claim 20, wherein the information associated with the data protocol comprises a Transport Control Protocol (TCP) sequence number used by the at least one traffic agent.

22. Apparatus according to claim 16, wherein the plurality of end-points comprises a source end-point and a destination end-point, and wherein the one or more data packets meeting the criterion comprise original packets sent from the source end-point to the destination end-point and echo packets returned from the destination end-point responsive to the original packets, both the original and the echo packets meeting the criterion.

23. Apparatus according to claim 16, wherein the network agents comprise Remote Network Monitoring (RMON) elements, in accordance with one or more applicable standards defined by the Internet Engineering Task Force (IETF).

24. Apparatus according to claim 16, wherein the network agents comprise software processes running on the nodes of the network at the respective locations.

25. Apparatus according to claim 16, wherein the network agents comprise stand-alone probes.

26. Apparatus according to claim 16, wherein the one or more network agents are operative to record times of

arrival of the at least one intercepted packet at the respective locations.

27. Apparatus according to claim 26, wherein the testing center is operative to determine, responsive to the recorded times of arrival, transit times of the at least one intercepted packet over the network links connected to the respective locations and traversed by the at least one intercepted packet.

28. Apparatus according to claim 27, wherein the one or more network agents are operative to intercept multiple data packets, and wherein the testing center is adapted to detect a jitter in transit of the packets over one of the links.

29. Apparatus according claim 26, wherein the determined transit times comprises round-trip transit times, determined by transmitting original packets from a source end-point to a destination end-point, and receiving corresponding echo packets returned from the destination end-point responsive to the original packets, both the original and the echo packets meeting the criterion,

wherein both the original packets and the corresponding echo packets are intercepted by the one or more network agents.

30. Apparatus according to claim 16, wherein the testing center is operative to determine which of the links in the network were traversed by the at least one intercepted packet.

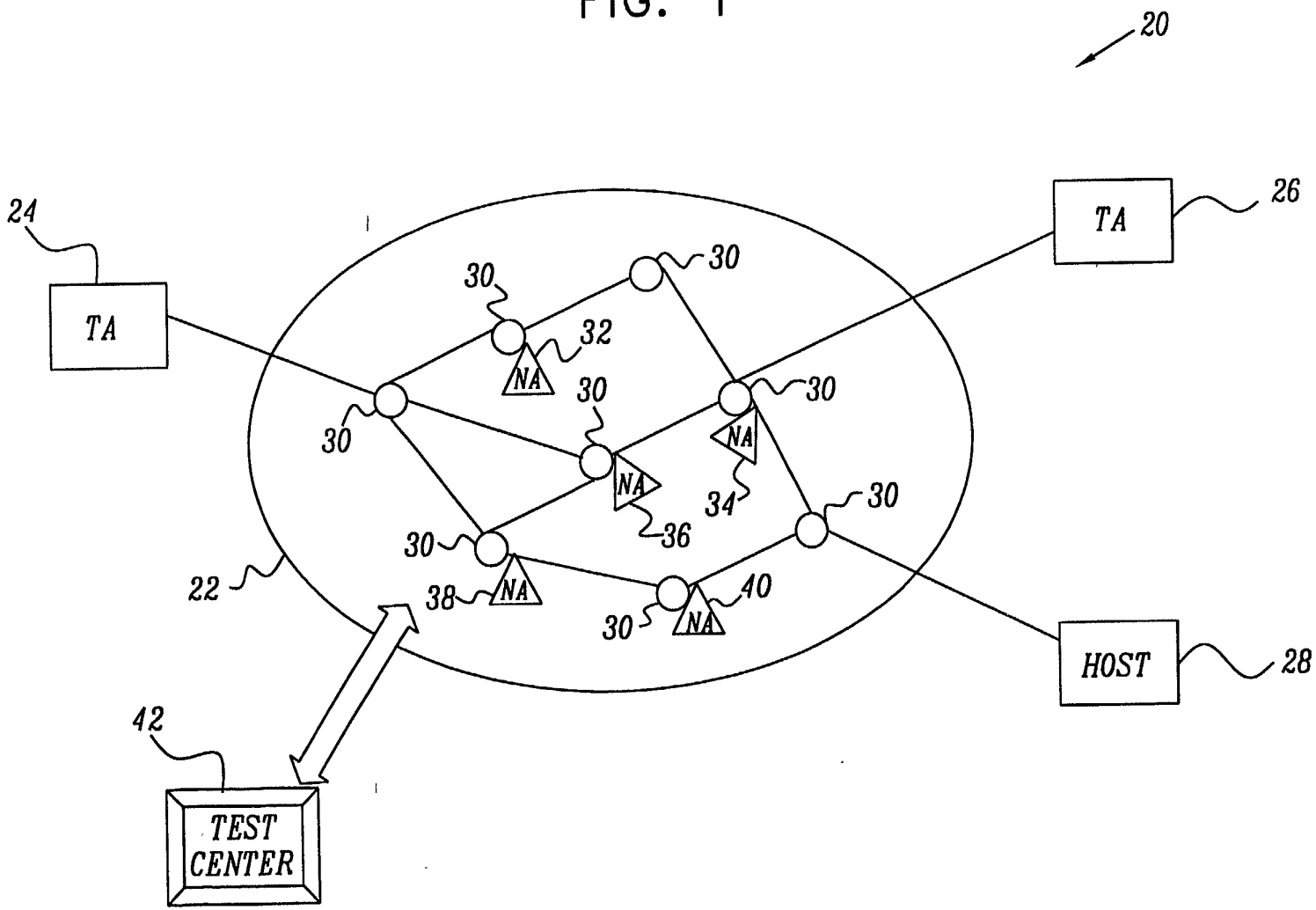
31. A computer software product for testing of a communication network having a plurality of end-points, using one or more network agents coupled to the network at respective locations, the product comprising a

computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to specify a packet filtering criterion and to engender transmission of one or more data packets meeting the criterion through the network from one of the end-points to another, such that at least one of the data packets meeting the criterion is intercepted using the network agents at the respective locations in the network traversed by the packets, which agents record information regarding the at least one intercepted packet at the respective locations, and which instructions further cause the computer to receive and process the recorded information so as to analyze a route of the at least one intercepted packet through the network.

ABSTRACT

A method for testing of a communication network having a plurality of end-points, using one or more network agents coupled to the network at respective locations. The method includes specifying at least one packet filtering criterion, and transmitting one or more data packets meeting the at least one criterion through the network from one of the end-point to another. At least one of the data packets meeting the criterion is intercepted using the network agents at one or more of the respective locations in the network traversed by the at least one of the data packets. Information regarding the at least one intercepted packet at the one or more respective locations is recorded and processed to analyze a route of the at least one intercepted packet through the network.

FIG. 1



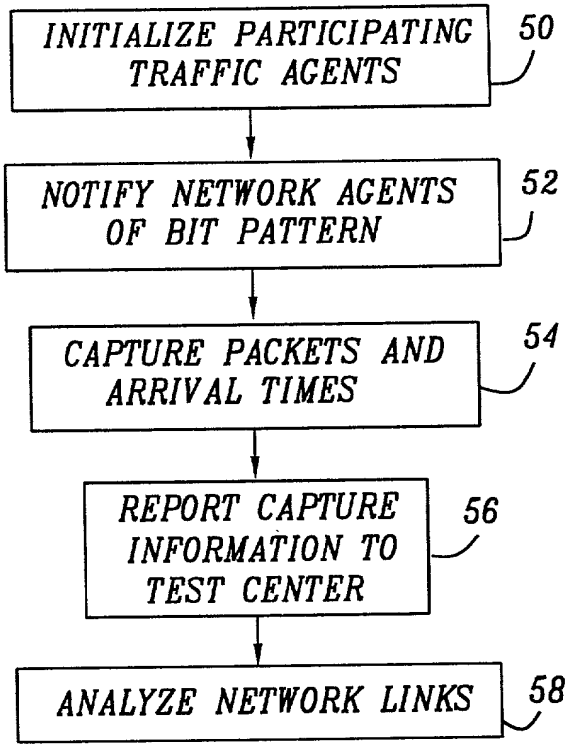

INITIALIZE PARTICIPATING TRAFFIC AGENTS
50
NOTIFY NETWORK AGENTS OF BIT PATTERN
52
CAPTURE PACKETS AND ARRIVAL TIMES
54
REPORT CAPTURE INFORMATION TO TEST CENTER
56
ANALYZE NETWORK LINKS
58

FIG. 2

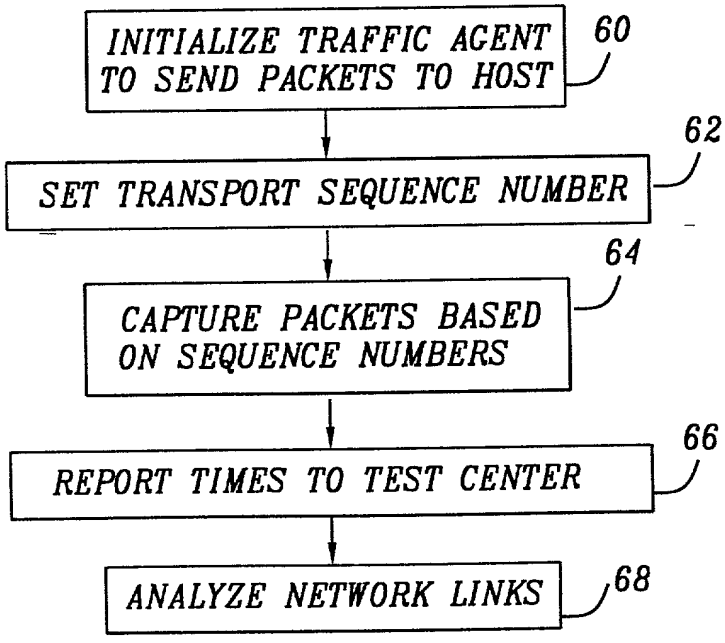

INITIALIZE TRAFFIC AGENT TO SEND PACKETS TO HOST
60
SET TRANSPORT SEQUENCE NUMBER
62
CAPTURE PACKETS BASED ON SEQUENCE NUMBERS
64
REPORT TIMES TO TEST CENTER
66
ANALYZE NETWORK LINKS
68

FIG. 3